Team Processes in Airway Facilities Operations Control Centers

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16. Abstract

In October 2000, the Airway Facilities organization plans to transition the National Airspace System (NAS) monitoring responsibilities to three regional Operations Control Centers (OCCs). Teams in these facilities will be different from those that currently exist in Maintenance Control Centers. A research team from the NAS Human Factors Branch, ACT-530, reviewed the implications of this new environment on potential OCC team performance issues. They conducted a two-pronged study. The first part examined team processes in current and future Airway Facilities (AF) environments. This involved assessing task analyses and flowcharts depicting workflow and communication processes for AF maintenance work and conducting site interviews at key field sites. The second part of the study focused on identifying key factors with implications for team performance in the literature and applying them to the OCC environment. The study led to nine recommendations for facilitating the transition to OCCs.

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Executive Summary

In October 2000, the Federal Aviation Administration Airway Facilities (AF) organization plans to implement the National Airspace System (NAS) Infrastructure Management program. This program focuses on NAS service management and improved customer service. The new structure includes a National Operations Control Center (NOCC), three regional Operations Control Centers (OCCs), and numerous Service Operations Centers and Work Centers networked by an integrated information infrastructure. The three OCCs will eventually replace existing Maintenance Control Centers (MCCs).

Though teams in the OCC are similar in many respects to those in the MCCs, there will be some differences. For example, unlike MCCs, the OCC team members will be divided by specialty. Good communications between these specialties will be essential for shared situation awareness and effective performance. Furthermore, specialists in the OCCs will be responsible for a much larger geographic area, employ standardized procedures, conduct service certification, and utilize a centralized database.

A research team from the NAS Human Factors Branch, ACT-530, conducted a two-part study to identify performance issues for teams in OCCs. The first part of the effort examined team processes in current and future AF environments. This involved assessing task analyses and flowcharts depicting workflow and communication processes for AF maintenance work and conducting site interviews at key field sites. The second part of the study focused on identifying key factors with implications for team performance in the literature and applying them to the OCC environment.

The assessment of potential performance issues led to nine recommendations for facilitating the transition to OCCs:

a. Clearly define individual specialist roles and responsibilities.

b. Establish and communicate OCC and individual position goals.

c. Determine the appropriate staffing levels at each position to avoid excessive workload.

d. Determine optimum workspace layout.

e. Provide communications and information databases to support operations.

f. Establish and train on standardized procedures.

g. Provide team training to transition personnel from the field and MCC environments to the OCC environment.

h. Ensure the performance standards and rewards to support operations within the OCC structure.

i. Establish a norm of effective communication and an atmosphere promoting information exchange from the beginning of the OCCs.

1. Introduction

In early 1990, the Federal Aviation Administration (FAA) Airway Facilities (AF) organization began to identify a new concept of operations in response to changes in technology, downsizing, diminishing budgets, and the push for increased government efficiency and accountability (FAA, 1999). This new, customer-orientated concept evolved into a three-tiered, centralized management process that emphasized the timely delivery of National Airspace System (NAS) services (FAA, 1994). The NAS Infrastructure Management (NIM) program will transition AF from a decentralized organization focused on equipment maintenance to a more centralized organization focusing on service management. The new organization will be comprised of a National Operations Control Center (NOCC), three regional Operations Control Centers (OCCs), approximately 30 Service Operations Centers, and multiple Work Centers networked by an integrated information infrastructure (FAA, 1997). The new AF structure is presented in Figure 1.

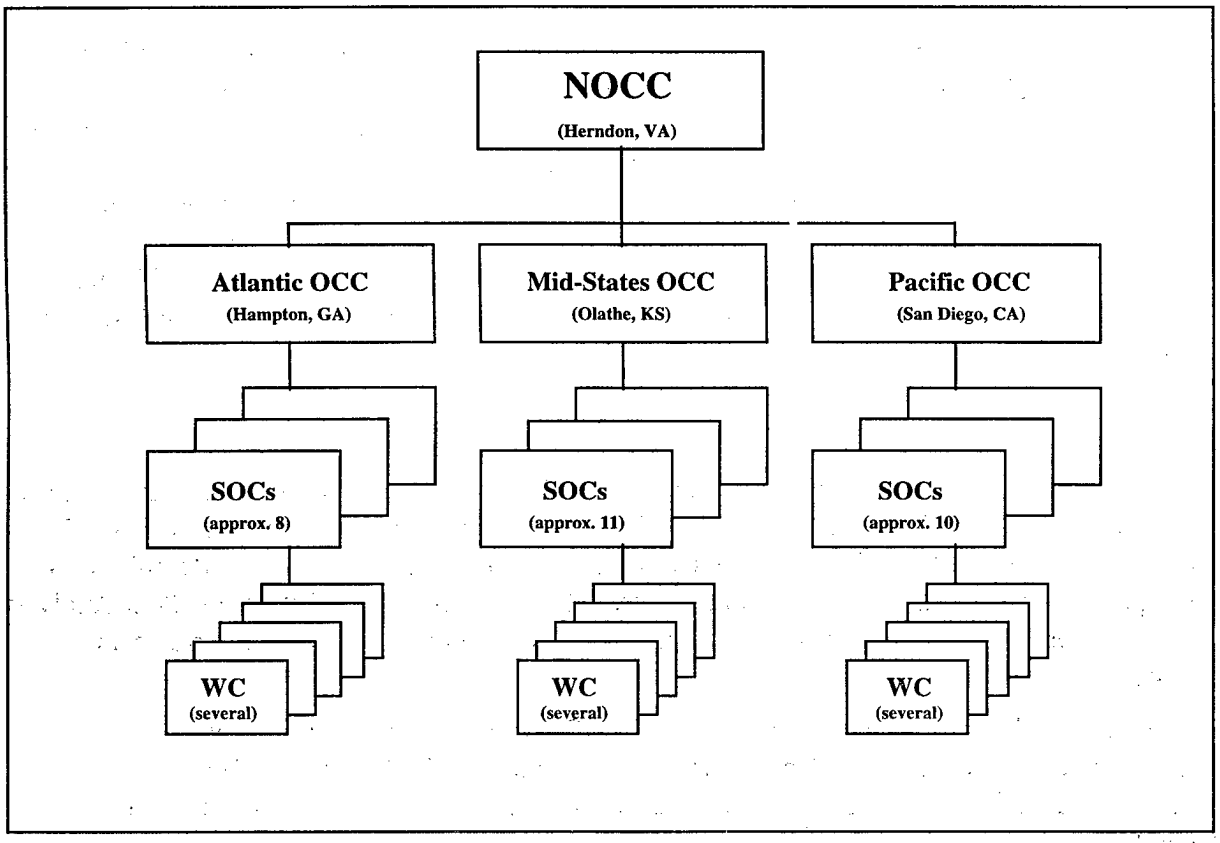

Figure 1. NAS Infrastructure Management Structure.

1.1 Background

Currently, there are 42 Maintenance Control Centers (MCCs) responsible for monitoring and coordinating scheduled and unscheduled NAS maintenance activities. NIM will transition monitoring responsibilities from these MCCs to three regional OCCs, each having responsibility

for approximately one third of the country. When implemented, OCCs will monitor NAS service and provide status information to customers, coordinate maintenance activities, and perform remote monitoring and maintenance (FAA, 1999). Consolidating these maintenance operations into an OCC will require new work processes and team relationships for AF specialists.

1.2 Scope

This document provides an examination of team processes in the current and proposed AF environment based on the examination of literature and site visits. It includes a review of team literature on key concepts and relates them to teams in the OCC environment. In particular, it identifies characteristics of effective teams and factors that can influence team effectiveness and applies them to the AF environment. It outlines team concepts relevant to the AF environment and suggests guidelines for enhancing effective team operations in centralized monitor and control environments.

2. Methodology

A team of researchers from the NAS Human Factors Branch (ACT-530) of the FAA William J. Hughes Technical Center conducted this study. We took a two-part approach to the study. First, we sought to define the current and future team structure. Our approach for this part of the study was to collect data on the current structure of MCC teams and the future structure of OCC teams through analyzing job task analyses and workflow processes, reviewing information from NIM documents, and conducting structured interviews at selected field sites. The second part of the study was to survey the literature on teams for areas applicable to the future OCCs. We then used the results of the literature study to identify key areas of importance for team performance in the future OCCs.

2.1 Analysis of Job Task Analyses and Workflow Processes

The FAA has two major task analysis documents for the AF environment; the Job Task Analysis for Maintenance Control Center Specialists (SFI, 1994) and the FAA Airway Facilities Job Task Analysis (CTA Inc., 1993). Although we examined both of these documents to identify tasks that require communication and coordination, only the FAA Airway Facilities Job Task Analysis contained enough detailed information on communication and coordination to perform an analysis.

We conducted additional analysis using a set of 10 flowcharts depicting workflow and communication processes for AF maintenance work contained in the Airway Facilities Organizational Effectiveness Study (McManis Associates, Inc, 1994). The 10 flowcharts covered

a. Air Route Traffic Control Center (ARTCC) preventative maintenance,
b. ARTCC corrective maintenance,
c. General NAS (GNAS) in support of ARTCC operations preventative maintenance,
d. GNAS in support of ARTCC operations corrective maintenance for radar,

e. Communications,

f. Automation,

g. NAVAIDS,

h. GNAS in support of terminal/advisory operations preventative maintenance,

i. GNAS in support of terminal/advisory operations corrective maintenance for tower/FSS operations, and

j. GNAS flight inspection.

These flow charts are based on data collected from five site visits including Memphis, Salt Lake City, Seattle, Dallas/Ft. Worth, and Oakland.

2.2 Site Visits

The research team visited and conducted site interviews at the NOCC, Southern California Terminal Radar Approach Control (SCT) MCC, and the Prototype Operations Control Center (POCC). The purposes of these visits were to characterize teams in the current AF environment, define the anticipated OCC operating environment, and identify the implications for teams in the new organization.

2.2.1 National Operations Control Center

The NOCC is co-located with the Air Traffic Control Systems Command Center at Herndon, VA. It monitors critical situations as they evolve and notifies, mobilizes, or directs key organizations. It also coordinates these events with Air Traffic (AT) and AF. This site was chosen because it represents one of the first steps toward the implementation of the future NIM environment, and the physical layout and organization of the NOCC will be mirrored in the OCCs.

2.2.2 SCT Maintenance Control Center

The SCT MCC is located at San Diego and is responsible for monitoring facilities and services in portions of California, Nevada, and Arizona. The facility operates 24 hours a day, 365 days a year and is staffed by seven two-person teams including a NAS Operations Manager (NOM) and NAS Area Specialist (FAA, 1997). We conducted structured interviews at this site to better understand teams in the current MCC environment.

2.2.3 Prototype Operations Control Center

At the POCC in San Diego, we interviewed individuals involved in establishing the Pacific OCC. The interviewees were selected because they are collaborating in the design of the OCC facility and development of the OCC infrastructure and procedures. As a result, they possessed a detailed knowledge of the planned OCC operating environment and teams.

3. Results

3.1 Analysis of Task Analyses and Flow Charts

We identified 588 tasks in the FAA Airway Facilities Job Task Analysis (CTA Inc., 1993) based on events to which the NOM must respond. Out of these 588 tasks, 300 directly involved voice communications. The majority of the voice communications tasks (168) involved coordination with a technician, followed by 129 tasks directly involving communication with AT. Other major coordination points were

a. the General Maintenance Control Center (GMCC) (72 tasks),

b. another NOM (107 tasks),

c. the NOCC (15 tasks),

d. military, weather, flight service stations, or traffic management unit (68 tasks),

e. telecommunications companies (27 tasks),

f. contractors (22 tasks), and

g. other, including local services such as police and fire (69 tasks).

The number of tasks attributed to each individual group adds up to more than the total number of voice communication tasks because, for many tasks, the point of coordination may vary depending on the circumstances, such as who reported the outage. This analysis highlights the significant role that voice communications play. The analysis also shows communication processes between key groups both within and external to AF.

We obtained further information on the structure of communication flow through analyses of flow charts depicting workflow and communication. Analyses of the flowcharts showed that of the communications across the AF organization sampled,

a. 24% was between the GMCC and technicians,

b. 18% was between NOMs and technicians,

c. 15% was between technicians and AT,

d. 11% was between GMCC and NOMs, and

e. 11% was between NOMs and AT/Automated Flight Service Station (AFSS).

The communication flows that were represented least in the flowcharts were

a. GMCC and AT (8%),

b. technician-to-technician communication (4%),

c. technician to AT/AFSS or GMCC to Sector Field Office (SFO) (2%),

d. GMCC to AT/AFSS, SFO to technician, and technician to Aviation Standards (1%), and

e. other flows (less than 1%).

In both of these analyses, the communication count or percentage represents only the number of tasks that require a particular path of communication, without any weighting for the frequency of occurrence. The percentage of communication that actually occurs in the field may differ significantly based on the occurrence of particular events. For example, according to the flowcharts, a GNAS preventative maintenance requires 20 incidents of communication between a technician and AT. The flowchart for GNAS radar corrective maintenance shows all of the coordination with AT occurring between the NOM and AT with no communications between the technician and AT. If the preventative maintenance occurred three times more often than the radar corrective maintenance, the percentage of total communications between member groups would be significantly different. Thus, the critical communication pathways could significantly vary from one AF group to another or from year to year. However, the primary communication pathways will likely remain critical, despite regional and seasonal fluctuations.

3.2 Structured Interviews: MCC vs. OCC Teams

Consolidating maintenance, monitoring, and coordination activities will necessitate changes in the way operations are performed. Although operations in the OCCs will be similar to the MCC, there are several differences that have the potential to affect the OCC team.

3.2.1 Specialization

Specialists at the MCCs respond to outages regardless of facility type and so possess a good awareness of the status of the entire NAS. In the OCC, positions will be more specialized. In the OCC, specialists will have intimate knowledge of a particular type of facility or service but will need to communicate closely with other specialists and the Watch Lead to maintain awareness of the implications of others services on their area. Thus, it will be critical for each specialty to communicate information to other specialties.

3.2.2 Geographical Locality

The OCC will have a much larger geographical area of responsibility. This will affect the OCC specialist in three ways. First, they will have to develop relationships with a variety of customers, most of whom they will never meet face-to-face. Team members will have to establish relationships through distributed forms of communication such as telephones and faxes. Second, the team members will be more geographically dispersed and the number of distributed team members will be greater. Third, because the geographic areas of responsibility are much larger, they encompass a broader range of climactic and other site-specific differences. For example, some facilities are in remote locations and require dog sleds or snowmobiles to access, and others facilities may be subject to flooding.

OCC team members will be responsible for a larger number but fewer types of facilities. The increased number of facilities and services being monitored could potentially lead to an environment characterized by higher demands. Research indicates that internal communications tend to deteriorate under these conditions, resulting in decreased team effectiveness.

Table 1 provides a comparison of MCCs and OCCs and summarizes the team implications. We calculated the average area of responsibility for MCCs and OCCs by dividing the area of the United States by the number of MCCs (42) and the number of OCCs (3) respectively. We estimated the average number of facilities and services supported by an MCC and OCC specialist based on data contained in the Facilities and Services Equipment Profile database. We determined the remaining items based on our review of NIM documentation.

Table 1. Characteristics of MCCs and OCCs and Their Team Implications

Variable	MCC	OCC	OCC Team Implications
Average Area of Responsibility (square miles)	88,519	1,239,265	more dispersed more distributed decision making centralized database required
Average Number of Facilities and Services	688	1,950	expanded monitoring responsibilities increased need for effective communications reliance on distributed communications
Level of Specialization	Low	High	increased need for effective communications distributed situational awareness distributed decision making
Procedures	Non-standardized	Standardized	need well defined roles

3.2.3 Standardization

Currently, procedures between MCCs are not standardized and differ significantly by region and facility. The NIM program has implemented an effort to standardize MCC operations. These standardized MCCs are characterized by standardized hardware, software, procedures, databases, and training (AOP-30, 1999). The procedures in an OCC will be standardized.

3.2.4 Internal OCC Teams

The exact OCC staffing levels have not been determined. Current estimates suggest that 68 individuals will be assigned to the OCC with 50 personnel on the operations floor. The OCC operations staff will most likely comprise a Help Desk, Watch lead, Communications, Telecommunications, Surveillance, NAVAIDS, Automation, Environmental, and Traffic Management Unit (TMU) (an AT position) specialists. The OCC anticipates staffing a minimum of two specialists for each specialty position during the day shift.

Based on the structured interviews, we identified some of the most common communication paths within the OCC (see Figure 2). Only half of the figure is labeled for clarity, as the second half of the oval is supposed to be a mirror image of the labeled half. The lines connecting the

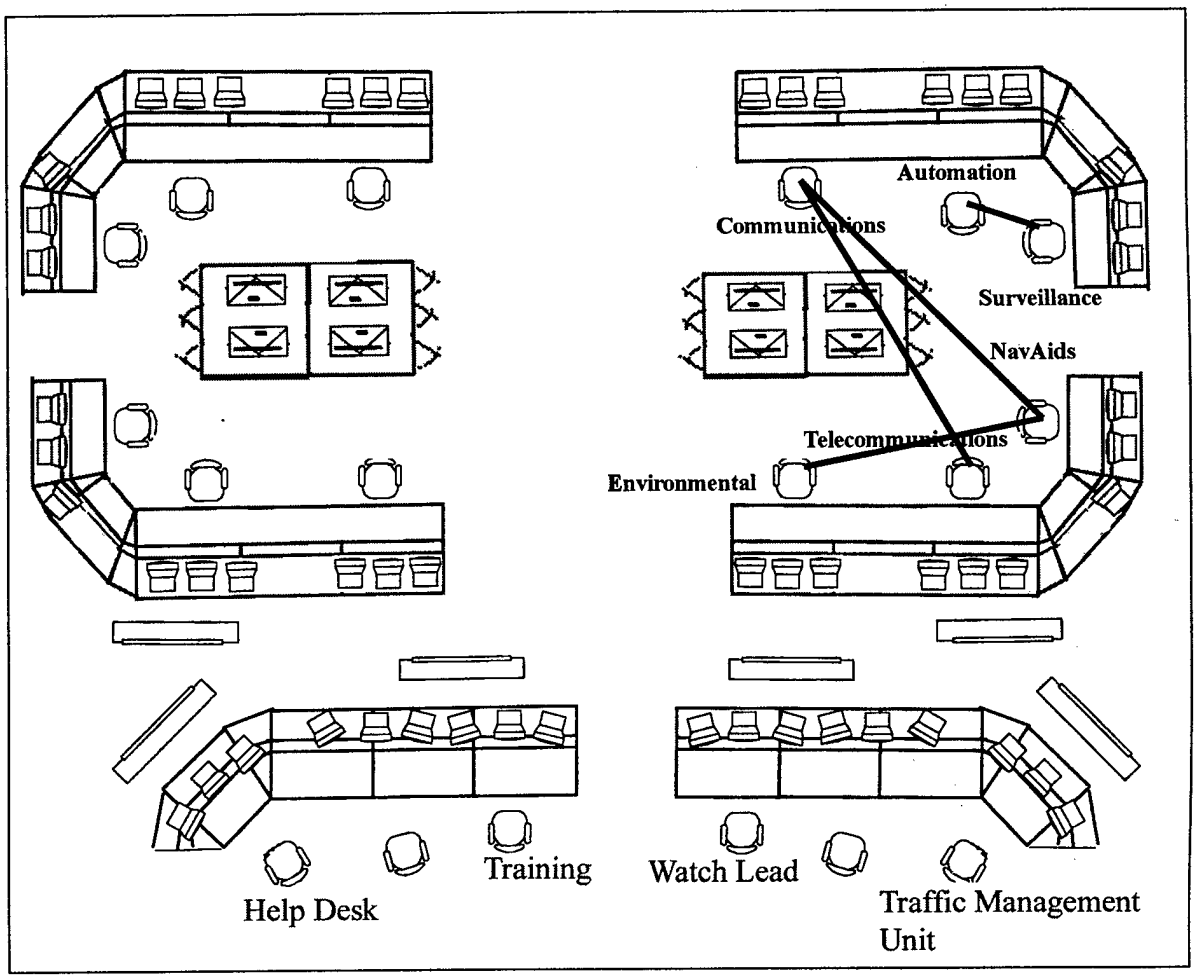

Figure 2. Common Operations Control Center internal communications paths.

specialty positions in this figure are based on a preliminary assessment of the frequency of interactions. However, the incidence of interactions should be validated through additional research or through data captured in an operational environment. The solid lines depict the most commonly anticipated interactions between team positions. Though each of the OCC specialists will need to coordinate with each other, communications between some of the specialty positions will be particularly frequent, such as interactions between the NAVAIDS and Environmental specialist.

We did not depict the communications between the Watch Lead or Help Desk and the specialty positions. The Help Desk specialist will forward incoming calls to the appropriate specialty position. The Watch Lead will be required to gather status information from each specialist. Both the Watch Lead and the Help Desk are anticipated to communicate frequently with each of the team positions.

3.2.5 External Teams

The OCC specialist will be required to coordinate with collocated members, such as other OCC specialists and with remote personnel, such as AF Systems specialists, AT, and other FAA and non-FAA organizations. As such, these teams will rely on distributed applications that will include a centralized database for accomplishing their work.

Based on the results of the structured interviews, Figure 3 provides the most common groups that OCC specialists will be expected to contact outside of the OCC. Heavier lines indicate interactions that are more frequent. The TMU position is presented in this figure, even though it may be located internally at the OCC. The most common communication mechanism will most likely be telephone; however, email, voicemail, internet web sites, and faxes may also be used.

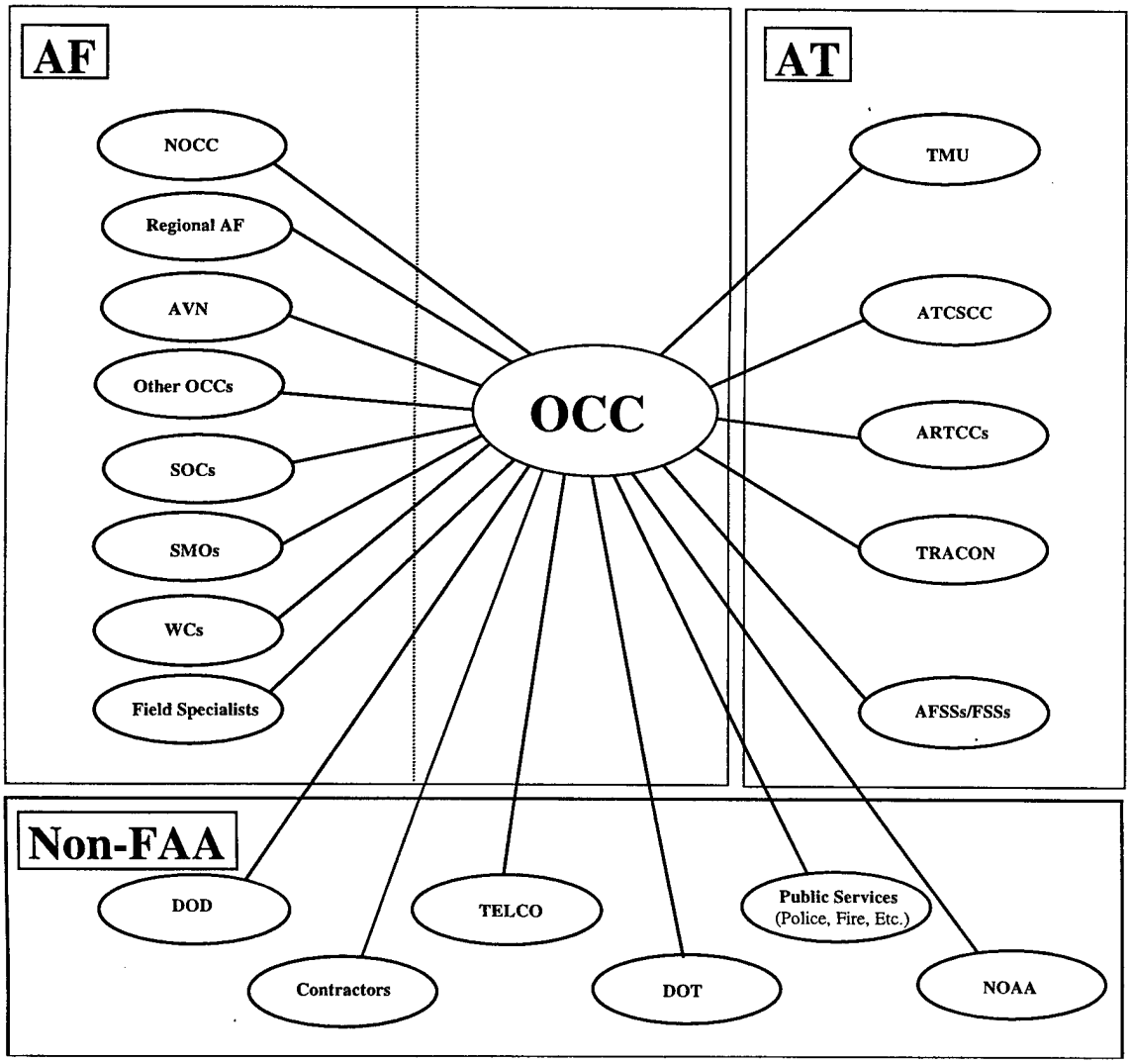

Figure 3. Common Operations Control Center external communications paths.

OCC communication mechanisms will most likely be very similar to those in place in MCCs today. Currently, the preferred method to contact a field specialist is the telephone or radio, especially at night or when immediate action is required. The interviewees estimated that MCC specialists spend as much as 50% of their time on the telephone performing coordination reporting. The goal is to reduce telephone usage to 20-30% in the OCC. If the MCC specialist is unable to reach the field specialist by telephone, he or she will use a pager. Pagers represent the best method to contact an onsite specialist for a high priority item during working hours, and the page is often followed by an email with additional information. Email will also be relied on heavily, particularly to transmit information such as documents to remote users. The internet as a mode of communication will likely become more prevalent in the OCC environment than it is in the MCC because the centralized database will be available.

4. Literature Review

The second part of the study involved examining the literature, identifying topics relevant to the OCCs, and applying relevant research to the AF environment.

4.1 What Is A Team?

Over 50 years of research have been conducted on the subject on teams and teamwork in organizational psychology, sociology, social psychology, and management. Several competing theories, definitions, and taxonomies have been proposed. This section provides a review of some relevant literature and presents a working definition that will serve as the basic description for teams in the current effort.

There are many different definitions of teams present in the literature, some of which are presented in Table 2. A common denominator to these definitions is that a team requires the interaction of two or more people to accomplish a common task, objective, or goal. This definition can be thought of as specifying three minimum requirements for a team. First, for a team to exist, it must consist of two or more individuals. Although this definition sets a minimum number of members, it does not set a maximum size requirement. Second, the individuals on a team must be striving to accomplish a common task, objective, or goal. Even if a group of several individuals are interacting, if they are not working together to achieve a common goal (e.g., individuals at a party), they are not a team.

The third component to a team is that team members must interact in their effort to achieve their common goal. This interaction is not restricted to same time, face-to-face, verbal communication. Some teams, such as virtual teams, rarely or never see each other face-to-face and communicate largely through electronic media.

4.1.1 Team Characteristics

Teams can be differentiated on the basis of size, roles, structure (including interaction of members), goals, and cohesiveness. Team characteristics are important factors in effective team performance. Different characteristics are appropriate for different circumstances and tasks. A team with the right set of characteristics for one task may be completely wrong for another task.

Table 2. Team Definitions

Reference	Definition
Morgan, Gluckman, Woodard, Blaiwes and Salas (1986)	*"A team is a distinguishable set of two or more individuals who interact interdependently and adaptively to achieve specified, shared, and valued objectives "(p. 6).*
Rifkind (1996)	*"A team is a diverse group of people who are interconnected with shared responsibilities and strive toward mutually defined goals. A team works within the context of other groups and systems"* (p. 7).
Salas, Dickinson, Converse and Tannenbaum (1992)	*"A team is two or more people who interact, dynamically, interdependently, and adaptively toward a common and valued goal, who have been assigned specific roles or functions to perform, and who have a limited life-span of membership"* (p. 4).
Sian and Robertson (1996)	*"A team is two or more individuals working interdependently to complete a specific task"* (p. 17).
Urban, Weaver, Bowers, and Rhodenizer (1996)	*"A team is a set of two or more individuals working in an interdependent fashion toward a common and meaningful goal"* (p. 300).

A major characteristic of groups is that they have implicit shared beliefs and expectations, called norms. Norms are very important and can have a strong influence on group atmosphere, productivity, and performance. For example, a norm of not working very hard and just getting the bare minimum done may develop. In contrast, a norm promoting high performance and accuracy may develop in a group. It is vital that norms created in the OCC groups foster a focus on effective communication and an atmosphere promoting information exchange and high quality performance. Although norms often develop in an indirect way, a specific vision and concrete, well-defined goals would help promote a positive norm. Of equal importance are the behaviors and attitudes of the people at the highest organizational levels. The culture or tone of an organization is set by the highest organizational members and tends to trickle down to the lowest levels of the organization. If upper management does not share the desired attitudes and behaviors, it makes it extremely difficult to get lower level personnel to adopt and accept the desired behaviors.

4.1.1.1 Size

Based on the previous definition of a team, we have already defined the minimum size of a team as two. Although optimal team size is highly task dependant, the size of a team can have a significant impact on team performance (Swezey & Salas, 1992).

One possibility discussed for use in the OCCs is the use of two person teams at a workstation. Morrisette, Hornseth, and Shellar (1975) investigated the effects on performance of one person versus two-person teams in monitoring tasks (cited in ACD-350, 1994). In one condition, the displays were monitored by a single team member and, in the other; they were equally divided between two team members. The authors reported that two-person teams were favorable because

they resulted in reduced response times. However, they noted that this might not be as effective in other situations.

4.1.1.2 Roles

A role refers to the set of behaviors characteristic or expected of members in a particular situation or position within a group. According to Forsyth (1990), role ambiguity and role conflict are sources of both stress and low morale in the workplace. Role ambiguity can occur when the employee is uncertain of policies, objectives, or expectations. Role conflict occurs when the employee is faced with conflicting requirements, rules of operation or expectations, or when an individual's goals are not in agreement with the goals of the team. The potential for role ambiguity and role conflict is always present when an organization changes policies, objectives or expectations, as is the case in moving toward OCCs.

How can role ambiguity and conflict be minimized in the OCCs? One recommendation is to ensure that the task goals are clear, concrete, and objectively stated. Clearly defined, specific procedures should describe how to accomplish the goals. These procedures should also provide guidelines as to what roles and goals should take priority in the case of a conflict. It is also important not only that the goals be defined, but that the team members understand the goals. Every member of the team should be able to state the goals that need to be achieved and the approach to meeting those goals. Each member of the team should understand his or her role in achieving the goal. All task responsibilities should be concrete and unambiguous.

4.1.1.3 Structure

The structure of the team is the pattern of relationships between the individual group members. Salas et al. (1992) describe a continuum of team structure with highly structured, interdependent teams at one end of the continuum and teams with highly individual tasks and minimal interaction at the other end of the continuum. Figure 4 illustrates the concept.

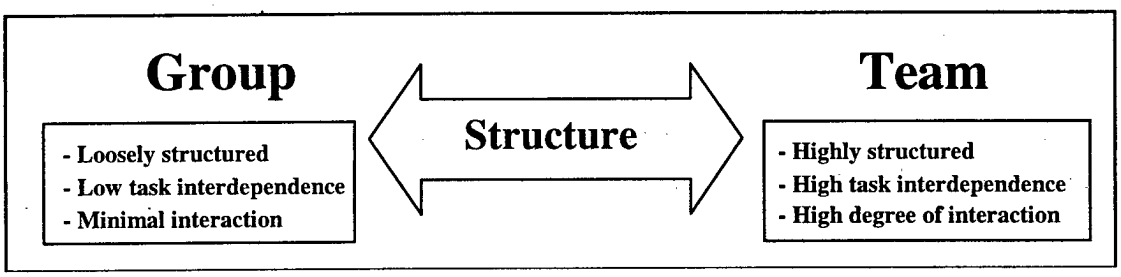

Figure 4. Continuum of structure as a team characteristic.

Central to the team structure continuum is the concept of task interdependence. Task interdependence refers to the amount of communication, coordination, and cooperation required to successfully perform the task. In essence, it is the degree to which the members of the group must depend on each other to successfully perform the task. As the amount of task interdependence increases, so do the requirements for communication and coordination.

Most people think of teams as having a high degree of task interdependence. In these highly interdependent teams, all group members jointly diagnose, problem solve, and collaborate to complete the task. An example of such a team might be a team working on launching a new advertising campaign. On the other extreme are teams with low task interdependence. These team members work largely autonomously with minimal interaction. Sales teams organized by territory are an example of such a team. Between these two extremes is a third model in which members of a team sometimes work independently and sometimes work interdependently. Similar to the organization of sales teams by territory, currently, each MCC has a territory that it is responsible for. In the OCCs, the organization will no longer be by geographic region, but by specialty. As the areas of the NAS become increasingly interconnected and interdependent, the specialty areas will have an increasing level of task interdependence, while still maintaining some degree of task independence in other situations.

4.1.1.4 Communication

Communication is highly related to interdependence and, as such, helps to shape the structure of the team. The importance of effective communications and coordination was underscored by a study that stated, "as in other technological endeavors, a high percentage of operational errors involves breakdowns in communications, coordination, and group decision making" (National Research Council, 1997, p. 150). Communication can be defined as the exchange of information between individuals. Communication in a team serves two main purposes: the exchange of information between team members and the coordination of shared resources and group activities (Schlicter, Koch, & Burger, 1997). Whereas good communication is key to effective team performance, the lack of proper communication can result in reductions in the quality of work and performance, high levels of stress and frustration, loss of situational awareness, and an increased incidence of errors (Sian & Robertson, 1996).

Interaction between team members can take different forms depending on the time and place of the communication. Figure 5, based on Schlicter et al. (1997), presents some examples.

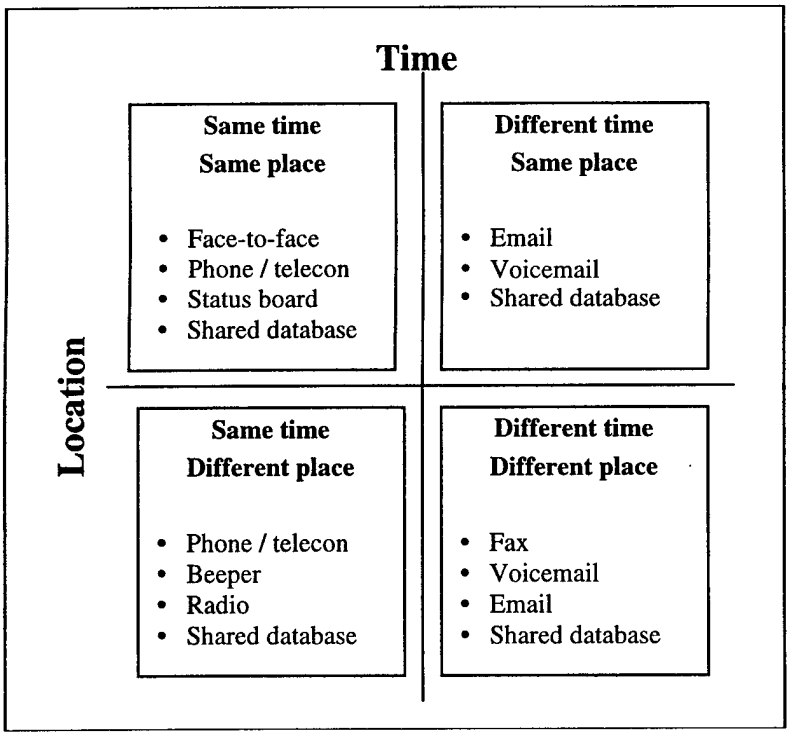

Figure 5. Preferred communication media based on time and space distinctions.

There are some types of teams, such as virtual teams, which rarely or never see each other face-to-face and communicate largely through electronic media. Warkentin, Sayeed, and Hightower (1997) note that many organizations have formed these types of teams, which are characterized by geographically distributed workers collaborating on a task mainly through the use of electronic media. The authors reported that communication effectiveness for virtual teams was similar for face-to-face teams, but that face-to-face team members reported higher levels of satisfaction. Straus and McGrath (1994) report that although the quality of work is similar for virtual teams using computer-mediated communication and face-to-face teams, productivity largely favored face-to-face interactions, particularly for tasks that require a lot of communication and coordination. When electronic media is used to communicate, particularly in time-pressure situations, normal politeness often decreases, which can eventually lead to negative relationships (Karau & Kelly, 1992). The use of electronic media for communication may require that specialists put additional effort into politeness that comes naturally in face-to-face and telephone communications.

The team members' locations and whether the communication takes place in real-time or is delayed largely determine the communication media adopted by a team. The communications media employed in the OCC will most likely be very similar to those used in the MCC today, with additional reliance on electronic communication. Currently, the MCCs rely heavily on telephone communications, representing a significant number of activities in the task analysis. With the OCCs representing approximately one third of the United States, if the telephone is the primary method of communication, the volume is likely to reach unmanageable proportions. As the OCC will be responsible for a larger geographic area, the opportunity for face-to-face communications will decrease, increasing the usage of alternatives such as electronic media. The

OCCs will most likely use a combination of communication media, depending on the task and situation. For example, communications between OCCs and field technicians, because they will not be located in the same place, will take the form of same time, different place, or different time, different place described in Figure 5. Care should be taken to define what type of communication media should be used for different situations that the specialists will face. This is particularly important based on research showing that communication through electronic media can have the potential for reducing satisfaction and productivity for some tasks.

Communication patterns can be described as centralized or decentralized. Centralized communication patterns are when the communication flows to and from one source. This pattern of communication is more effective for small groups. In decentralized communication, instead of flowing to and from one particular source, the information exchange is equal. This type of communication pattern is better for more complex tasks, leading to better performance for the team.

Successful communication is extremely important to the success of teams in OCCs. The communication patterns within the OCCs may contain aspects of both centralized and decentralized communication. The centralized aspects of the communication structure imply that the person or persons who receive the initial contact information is in a leadership position. In this situation, other group members may experience dissatisfaction from not being "in the loop." This could be of particular importance if the person in the Help Desk position is not an effective communicator. Specific communication patterns and a norm for good communication skills need to be developed. Instead of discussing or communicating about every issue, specialists need to learn or be trained to identify information that is most likely not known by others who would be affected by it.

Situational influences can have a significant impact on the communication among the group members. Team members who may otherwise communicate effectively, dispersing information to all affected, may neglect to inform other personnel that the problem may directly affect them when under time pressure to get the job done or under high workload conditions (Salas et al., 1992; Urban et al., 1996). Often, the response to temporal pressure is to use established response patterns. An OCC specialist from an MCC background may abandon newly learned procedures and revert to familiar (MCC) procedures. Adequate time must be allowed for communication, and it may be helpful to develop particular communication processes for time-pressure or high workload situations. These processes should include specification of what communication medium to use (e.g., voice, fax, or email) under specific situations.

4.1.1.5 Cohesiveness

The cohesiveness of a team refers to the strength of member attachment either for the team itself (social or interpersonal cohesion) or for the task the team is trying to accomplish (task cohesion). Cohesiveness can be the result of many causes such as interpersonal attraction, liking for the task, commitment to the group, and group prestige or pride. Research on the effect of social cohesion on performance has had mixed results. Although social cohesion has been shown to facilitate communication, team members may spend more time on communicating socially and not as much time on the task. In other words, attachment to the group or members of the group

can sometimes interfere with the effectiveness of the group because group members may direct their energy to social activities rather than the task at hand. Higher task cohesion, however, may lead to better performance (Ivancevich & Matteson, 1996). Team members with high task cohesion may or may not share strong social bonds, however, they do share a commitment to reach a desired goal that cannot be achieved individually. This implies that the group members do, in fact, care about the success of the other members of the group because without them the goal cannot be reached. In general, higher cohesiveness has been found to correlate with better performance, a phenomenon known as the cohesive-performance effect. This effect, however, may have more to do with task cohesion than with social cohesion. For the OCCs, specialists sharing a strong commitment to reaching the specified goals will achieve task cohesiveness.

4.1.1.6 Goals and Rewards

According to Webster's dictionary, a goal is " The objective toward which an effort is directed." Just as the task can be interdependent, requiring interaction to complete, the objective or outcome for the team's work can be interdependent, depending on the performance of other team members to achieve. The outcome of the team's work consists of the achievement of goals and the associated rewards. Outcome interdependence can be established for groups, for individuals, or a combination of group and individual. In the advertising account example, the (highly interdependent) reward may be equally split between all members of the team. On the other hand, the sales team may have the (low interdependent) reward of commission on individual sales. A study of how the goals and reward structure can impact performance in an organization similar to AF is presented below.

4.1.2 Study of Teams in a Similar Corporate Organization

Wageman (1995) conducted a field study using service technicians at the Xerox Corporation. This organization has many similarities to the AF organization. At the time of the study, Xerox employed more than 15,000 people, of who about 12,000 were technicians who repaired machines. The organization is divided geographically into nine areas. Each of the areas is divided into districts. The districts are then broken into sub-districts either geographically or by machine type. If the work is divided geographically, each technician is responsible for a geographic area, no matter what machine requires work. If the work is divided by machine type, each specialist only works on a particular type of machine, no matter where in the district the machine was.

The Xerox work teams varied quite a bit on their level of interdependence. Some of the teams consisted of members who worked largely autonomously. These groups maintained highly rigid territories with individuals only working on their own machines. Many of these groups managed parts expenses for their machines alone, not as part of the group. These technicians developed a strong sense of personal responsibility for their machines. Other groups (called hybrid groups) had a mix of independent tasks and those requiring group decisions or actions. Still other groups shared responsibilities equally for repair calls and made collective decisions. In these groups, the technicians would take calls in the order of urgency, regardless of where in the district the machine was located. Thus, these groups maintained collective responsibility for responding to the repair calls from all of the customers in the district.

Xerox technicians conduct corrective maintenance based on customer calls about machine breakdowns. Customer calls come into a centralized dispatching office. Technicians periodically call the dispatch office to obtain the repair calls that have come in throughout the day. The technicians prioritize repair calls and track parts usage, using their own judgment about when to replace or repair parts. Between corrective maintenance calls, the technicians conduct preventative maintenance based on predefined schedules.

The Xerox technicians received formal feedback on individual performance and group performance. Individual performance could result in merit increases in salary, which was based on several factors including professionalism, customer satisfaction, and teamwork. Group performance could result in bonuses or paid vacations based on the district's performance. Group performance measures included response time, repair time, call rate, parts expenditures, machine reliability, and customer satisfaction surveys. The Wageman study introduced changes in the reward system creating group, individual, and hybrid rewards for the technicians.

Wageman's (1995) study found that the work could be performed well either independently or interdependently when the reward system matched the type of task (when groups that performed highly independently and received rewards based on individual work and groups that worked interdependently and received rewards based on the work of the group). Overall, manipulating the reward system tended to affect technician motivation rather than to influence group behavior. Although the group reward system had no independent influence on cooperative behavior, group rewards motivated groups with interdependent tasks and individual rewards motivated technicians with independent tasks. Hybrid rewards, in which 50% of the reward was based on group behavior and 50% was based on individual behavior, proved ineffective.

Performance for the highly independent groups was very high. Machine repair time was 20% faster than average, reliability was higher than national standards, and 100%of customers surveyed were satisfied. The highly interdependent group showed high levels of cooperation and effort, mutual learning, and felt responsible to other group members as well as a collective responsibility for all of the group's customers (this is representative of task cohesion). The hybrid groups in this study, in which members were sometimes asked to work as a group and sometimes as an individual, were not especially effective. The members of the hybrid group felt that adding the group elements to their work interfered with their ability to work on their task. Coordination and cooperation within these groups were weak and ineffective. Wageman warns against introducing interdependent group processes into high performing independent groups.

Another interesting finding of the study was that the preference for autonomy over time changed with the kinds of tasks and rewards they experienced. Technicians with a high preference for independent work, when faced with interdependent tasks and group rewards, came to accept and prefer interdependent work.

Whether the task and reward system at the OCCs are independent, interdependent or hybrid may have a significant impact on the ultimate performance at the OCCs. The tasks at the OCC may be considered more independent in the sense that instead of having a call queuing process that puts the responsibility for all of the equipment and services equally on all of the members, the specialists will have assignment of individual responsibilities based on specialty. The

independent groups in the Wageman study were extremely effective. However, if the specialists at the OCC are expected to work independently at some times (in their specialty area) and interdependently at other times (helping out someone else who is overloaded), the group is now faced with a hybrid structure. The hybrid structure in the Wageman study was the least effective group. Whether the tasks given to the specialists are independent or interdependent, the reward system should be congruent with the tasks.

4.1.3 Measures of Team Effectiveness

How do you know that the team, whether independent or interdependent, is effective? In Crew Resource Management, two types of effectiveness measures have been proposed: outcome measures and process measures (Helmreich & Foushee, 1993). Outcome measures gauge the end products of an effective team. Essentially, they are the result of a process. Examples of outcome measures might be reduced aircraft incidents and crew attitudes. Measures for the OCCs might include reduced number of outages, reduced duration of outages, and improved customer satisfaction. Process measures focus on the interaction that occurs to achieve these end goals; that is, how the task was accomplished. Examples of process measures are improved information sharing processes and more effective problem solving as a team. Both types of measures are used in assessing team performance. Table 3 provides a survey of several evaluations investigating teamwork in a variety of settings, including command and control teams, teams in industrial workgroups, aircraft maintenance teams, and experiments on teams in laboratory settings (Cannon-Bowers et al., 1992; Cannon-Bowers & Salas, 1997; Entin & Serfaty, 1999; Gwynne et al., 1996; Ivaturi et al., 1995; Johnston et al., 1995; Urban et al., 1996). The table identifies specific measures used for measuring different dimensions of teamwork including both process and outcome measures.

The most common outcome measures used in the studies surveyed were response latency and number of errors. The most common process measures were message count, message type and message content. Team effectiveness measures like those described in Table 3 have potential for use in the OCCs to evaluate the effectiveness of training efforts and the impact of changes in procedures. These measures could also be used to a limited extent in simulations to determine the impact of proposed procedural or software changes before implementing them.

Table 3. Survey of Team Dimensions and Measures

Dimension	Measure
Outcome measures	
Task / mission effectiveness	Productivity
	Quality
	Quantity
	Safety
	Successful task completion
	Quality of situation assessment reports
	Consistency of situation assessment reports
Task speed	Time to complete task
	Response latency
Task accuracy	Number of errors
	Omitted actions
	Erroneous assessments
	Aggregate accuracy
Workload	NASA Task Load Index
Process measures	
Communication / coordination	Message count
	Message type
	Message clarity
	Message timeliness
	Message accuracy
	Message content
	Message media
	Transfer of resources among team members
Situation assessment	Correctly assessing situation
	Agreement of team members mental model
	Changes in the individual's knowledge, skills, and abilities
Teamwork / cohesion / flexibility	Compensatory behavior
	Monitoring activities of other team members
	Giving and receiving feedback non-defensively
	Providing and seeking assistance when needed
	Anticipating tasks
Leadership / assertiveness	Providing instruction
	Taking action to correct errors
	Helping other members focus their activities
Decision making	Appropriate action and sequence

5. Conclusions

Based on the data and literature reviewed, there are certain positive steps that can be taken to facilitate teams in the OCCs. Some of these steps are already underway in the OCC development process, as follows.

a. Clearly define individual specialist roles and responsibilities.

   Critical to the success of the OCCs are clearly defined roles and responsibilities. Clearly defined roles and responsibilities can minimize stress and improve morale in the workplace.

b. Establish and communicate OCC and individual position goals.

   Clear goals should be established for the individual positions as well as the OCC as a whole. Clearly defined, specific procedures should describe how to accomplish the goals. These procedures should also provide guidelines as to what roles and goals should take priority in the case of a conflict. It is also important not only that the goals be defined but that the team members understand the goals. Every member of the team should be able to state the goals that need to be achieved and the approach to meeting those goals. Each member of the team should understand his or her role in achieving the goal. All task responsibilities should be concrete and unambiguous.

c. Determine the appropriate staffing levels at each position to avoid excessive workload.

   With the OCC concept, where division of responsibilities is by specialty, it is essential that there is sufficient staffing at each position to avoid excessive workload. If some specialty positions are to fill in for others in times of high workload (e.g., when the specialist in automation gets overloaded, the specialist in surveillance will help), specific roles and responsibilities should be spelled out for such special conditions.

d. Determine optimum workspace layout.

   Although we did not analyze the physical positioning of the specialists in the OCC, it is important that the specialist be positioned in a way that facilitates necessary communication. One version of the OCC floor plan places the Help Desk and Watch Lead at a position removed from the rest of the specialists. However, because these positions frequently interact with each of the specialists, it may be beneficial to place them in a central location.

e. Provide communications and information databases to support operations.

   The task analysis data, the analysis of the flowcharts, and the structured interviews highlighted the importance of communication to effective performance in the AF environment. OCC specialists will rely heavily on distributed means of communication, thus these modes of communication must be reliable and easy to use.

f. Establish and train on standardized procedures.

   The standardization of the MCCs is an important first step toward promoting effective team performance. Standardized procedures will be essential to the effectiveness of the OCCs. Standardized procedures with clearly defined team-member roles and responsibilities reduce the need for teams to expend time and resources defining these components. This promotes effective team performance and is particularly important for distributed teams (Sian & Robertson, 1996).

g. Provide team training to transition personnel from the field and MCC environments to the OCC environment.

   Positions at an OCC will be more specialized than those of an MCC. This has the potential of reducing the situational awareness between the specialists. The specialists at an OCC may have to put a conscious effort into communicating with the other specialists and sharing information. However, it would be inefficient for the specialists to share every bit of information that they come across with every other OCC specialist. Instead, the specialists may need to be trained to recognize what information is important or may have an impact on the specialists around them.

h. Ensure the performance standards and rewards to support operations within the OCC structure.

   As illustrated by the Wageman (1995) study of workers at Xerox, it is important to structure the reward system so that it is congruent with the type of group structure. Tasks that are structured to be worked on independently should have independent rewards, whereas tasks that are structured to be worked on interdependently should have interdependent rewards.

i. Establish a norm of effective communication and an atmosphere promoting information exchange in management.

   The research described in this paper illustrates the critical role of communication and information exchange. It is vital that norms created in the OCC groups foster a focus on effective communication and an atmosphere promoting information exchange and high quality performance. Although norms often develop in an indirect way, a specific vision and concrete, well-defined goals would help promote a positive norm. Of equal importance are the behaviors and attitudes of the people at the highest organizational levels. The culture or tone of an organization is set by the highest organizational members and tends to trickle down to the lowest levels of the organization. If upper management does not share the desired attitudes and behaviors, it makes it extremely difficult to get lower level personnel to adopt and accept the desired behaviors. Thus, it is important for all levels of the organization to adopt and behave in the desired way.

These recommendations are meant to smooth the transition from MCCs to OCCs. However, because groups are dynamic and evolve over time, even with these recommendations, optimal performance in OCCs will take some time. When the change to an OCC environment takes place, the new teams will need time to adjust and become familiar with the new procedures and with working in a more team-oriented environment. It is typical for new teams such as those in the OCCs to divide their time between establishing interpersonal relationships among group members and task completion. This oscillation between task and social behaviors is important to their ultimate effectiveness as a team.

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Acronyms

AF	Airway Facilities
AFSS	Automated Flight Service Stations
ARTCC	Air Route Traffic Control Center
AT	Air Traffic
FAA	Federal Aviation Administration
GMCC	General Maintenance Control Center
GNAS	General National Airspace System
MCC	Maintenance Control Center
NAS	National Airspace System
NIM	NAS Infrastructure Management
NOCC	National Operations Control Center
NOM	NAS Operations Manager
OCC	Operations Control Center
POCC	Prototype Operations Control Center
SCT	Southern California Terminal Radar Approach Control
SFO	Sector Field Office
TMU	Traffic Management Unit